25 *Albugo*

Division	:	*Mycota*
Sub-division	:	*Eumycotina*
Class	:	*Oomycetes*
Order	:	*Peronosporales*
Family	:	*Albuginaceae*
Genus	:	*Albugo*

Albugo (*Cystopus*) is a fungus. It is included in the family ***Albuginaceae*** of the class ***Oomycetes***. It causes ***white rust*** disease on ***land plants***. So it is popularly called ***white rust fungus***.

Occurrence

Albugo includes about 25 species. Of these, only seven species are found in India. Almost all species are ***parasitic*** on plant hosts. Some common species of *Albugo* and their hosts are given below:

Species	Host plant
Albugo candidus	All cruciferous plants
Albugo pomoeae pendurae	Sweet potato and Morning glory
Albugo bliti	*Amaranthus* sps
Albugo portulaca	*Portulaca* sps
Albugo tragopogansis	All members of Asteraceae
Albugo occidentalis	Spinach
Albugo platensis	Boerhaavia
Albugo evolvuli	*Evolvulus*

Highlights

White Rust

The ***white rust disease*** is caused by the fungus *Albugo*.

1. White or creamy yellow pustules on infected leaves, stems and flowers.
2. White colour is caused by white powdery ***sporangia***.
3. Local ***swellings*** at infected sites.

4. ***Discolouration*** of petals.
5. Malformation of stamens into leaf-like or club-shaped sterile structures.
6. ***White patches*** with powdery mass of spores and sporangia.

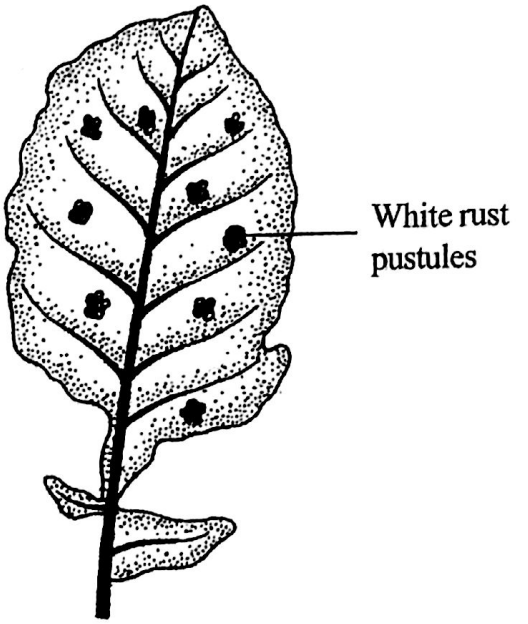

Fig.25.1: A leaf of Brassica showing white rust pustules.

Structure

Albugo is a ***white rust fungus***. It is a ***parasite***.

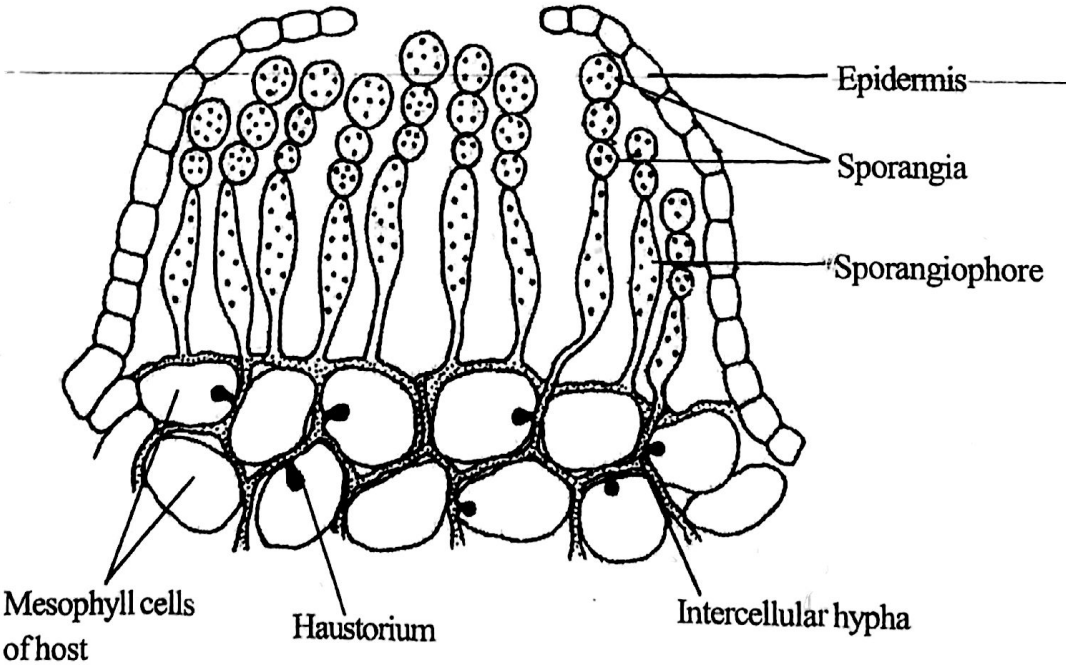

Fig.25.2: Albugo- A peripheral part of host leaf showing sporangial sorus

Fig.25.9: Diagrammatic life cycle of Albugo.

The vegetative body of *Albugo* is a ***mycelium.*** It ramifies in the ***intercellular spaces*** between the cells of the host.

It is ***haploid***.

It consists of many ***branched, septate, coenocytic*** hyphae. Septa are absent in actively growing young mycelium.

The hypha produces a knob-like structure called ***haustorium*** (pl.haustoria).

The haustorium penetrates the host cell and draws food materials.

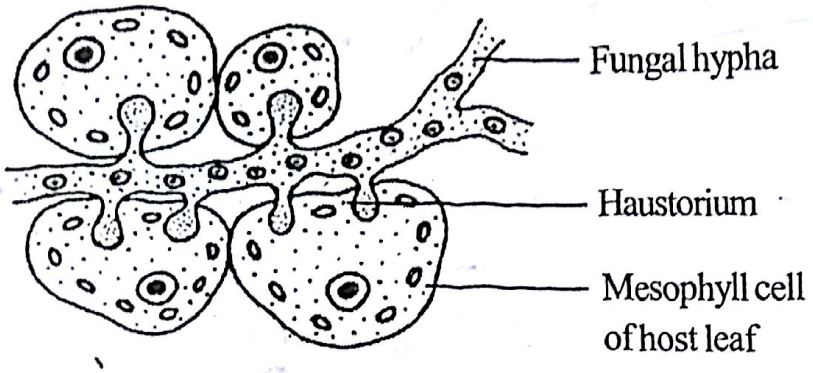

Fig.25.3: Albugo candidus - A part of intercellular hypha with haustoria in host cells.

The ***nutrition*** is ***heterotrophic***. *Albugo* absorbs its food from the living cells of the hosts by its ***haustoria***.

Highlights

Albugo

- *Albugo* is a ***fungus***.
- It is included in the family ***Albuginaceae*** of the class ***Oomycetes***.
- It is popularly called ***white rust fungus***, because it causes ***white rust disease***.
- All species of *Albugo* are ***parasitic***.
- The vegetative body of *Albugo* is a ***haploid mycelium***.
- The mycelium consists of many ***branched, septate, coenocytic hyphae***.
- The hyphal cells are ***multinucleate***.
- The hypha produces knob- like ***haustorium***.
- The haustorium penetrates the host cell and absorbs food materials.
- The mycelium grows and branches repeatedly in the intercellular spaces of the host.
- The hypha produces vertical branches called ***sporangiophores***.
- They are club- shaped.
- They are ***upright*** and ***parallel*** to one another.
- The sporangiophore develops a series of ***sporangia*** at its tip.
- The sporangium is ***hyaline*** and ***spherical*** in shape.
- It is ***multinucleate*** and ***smooth***.
- They are arranged in ***basipetalous*** manner.
- Host epidermis is ruptured due to the pressure of sporangia.

The contents of the sporangium divides into 6-8 pieces.
Each piece has a single nucleus.
Each piece develops a ***plasma membrane*** and ***cell wall*** around it.
Each cell develops two flagella to become a kidney - shaped ***zoospore.*** It is ***uninucleate.***
The sporangial wall ruptures and releases the zoospores.

Germination of Zoospore

Water is necessary for the germination of zoospores.
The zoospore swims for sometime in the water on the surface of wet leaf.
It looses its flagella and comes to rest on the leaf surface.

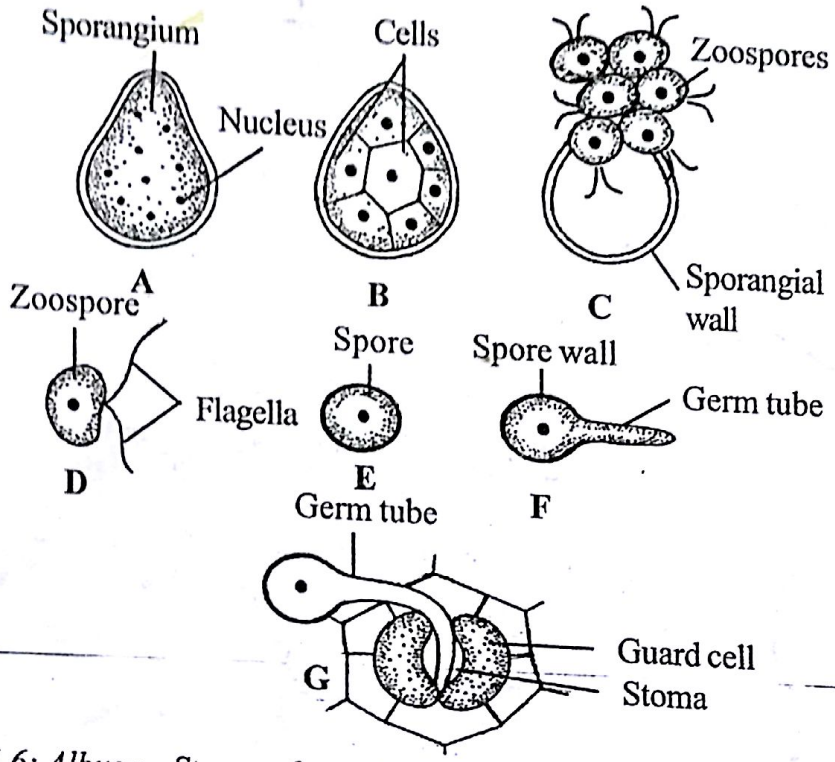

Fig.25.6: Albugo - Stages of germination of zoosporangium and zoospore.

The zoospore produces a ***germ tube*** which penetrates the host tissue through the ***stoma.*** This germ tube grows and forms a branched ***mycelium.***
If the climate is warm, the sporangium directly forms a germ tube and penetrates the leaf. Here, it grows into a ***mycelium.***

Sexual Reproduction

The sexual reproduction in *Albugo* is ***oogamous*** type.
The male sex organs are called ***antheridia*** and the female sex organs are called ***oogonia.***
Albugo is ***homothallic.***
Antheridium is borne on the ***male hypha*** and the oogonium is borne on the ***female hypha*** of the mycelium.
Some parts of the mature mycelium grow deep into intercellular space in the petiole or stem and produce sex organs. This leads to ***hypertrophy***, i.e., local swelling at these sites.

Oogonium

Oogonium is the ***female sex organ.***

It is a ***globular*** structure produced at the tip of the ***female hypha.***

Rarely, it is produced in the middle of the hypha. It is separated from the rest of the hypha by a ***septum.***

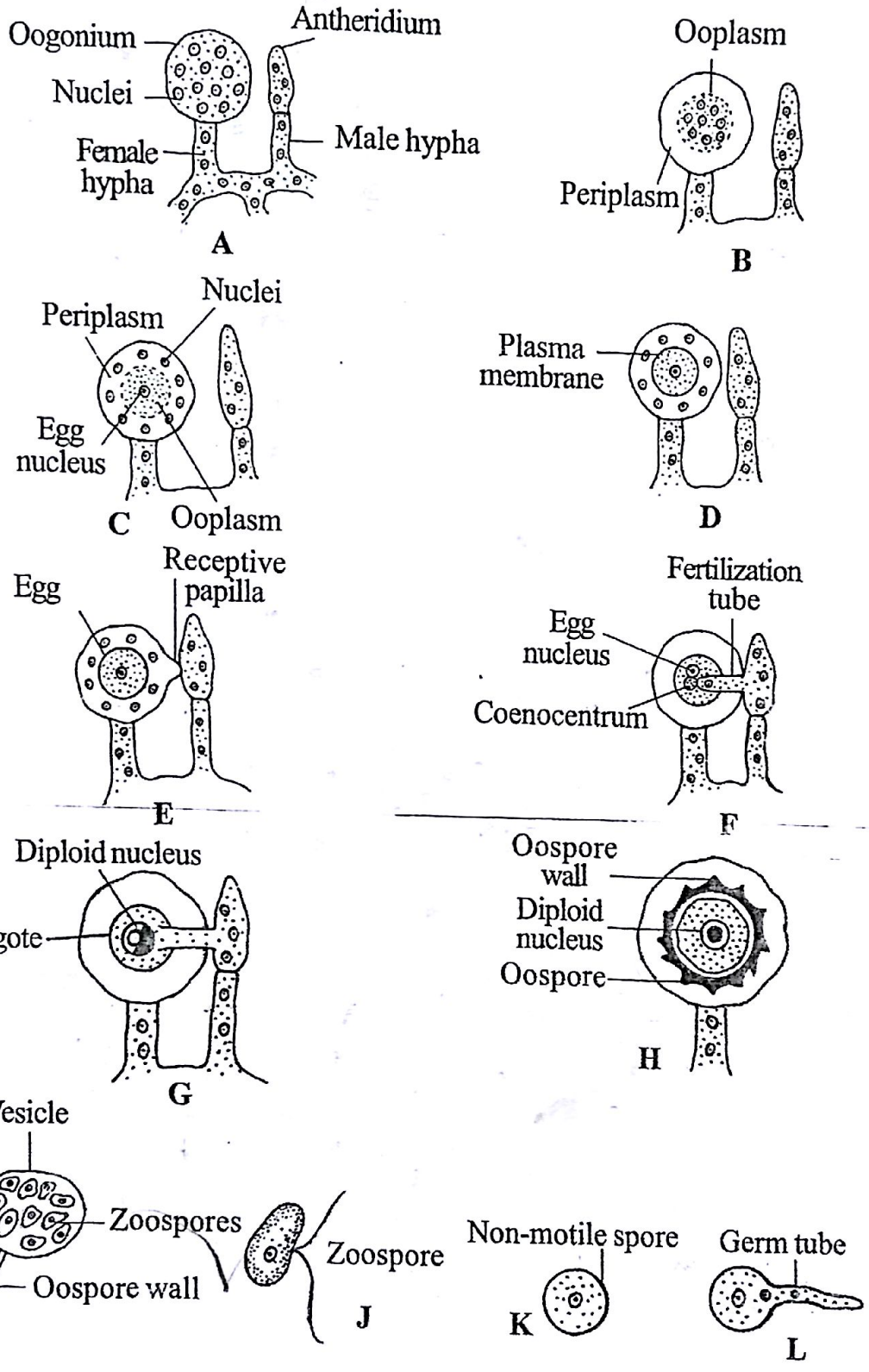

Fig.25.7: Sexual reproduction in Albugo candidus.

- The ***white mass of sporangia*** is exposed out through the ruptured epidermis. This is the characteristic feature of ***white rust disease***.
- The sporangia are spread by ***wind***.
- Nutrition is ***heterotrophic***.
- *Albugo* reproduces ***asexually*** and ***sexually***.
- Asexual reproduction takes place by ***sporangia***.
- The sporangia germinate and produce ***zoospores.***
- The zoospores germinate into mycelium.
- Sexual reproduction is ***oogamous*** type.
- The male sex organs are called ***antheridia*** and the female sex organs are called ***oogonia***.
- The male and female nuclei fuse together and form a ***diploid zygote*** (2N).
- The diploid zygote develops into an ***oospore***.
- The oospore undergoes ***meiosis*** and ***mitosis*** to produce ***biflagellate zoospores.***
- The zoospores penetrate the host plant and forms a ***new mycelium***.
- The life cycle shows ***alternation of generations***.
- The ***haploid phase*** alternates with the ***diploid phase***.

Reproduction

Albugo (*Cystopus*) reproduces by ***two*** methods .
They are-

1. *Asexual reproduction*
2. *Sexual reproduction.*

Asexual Reproduction

The asexual reproduction takes place by means of ***sporangia.***

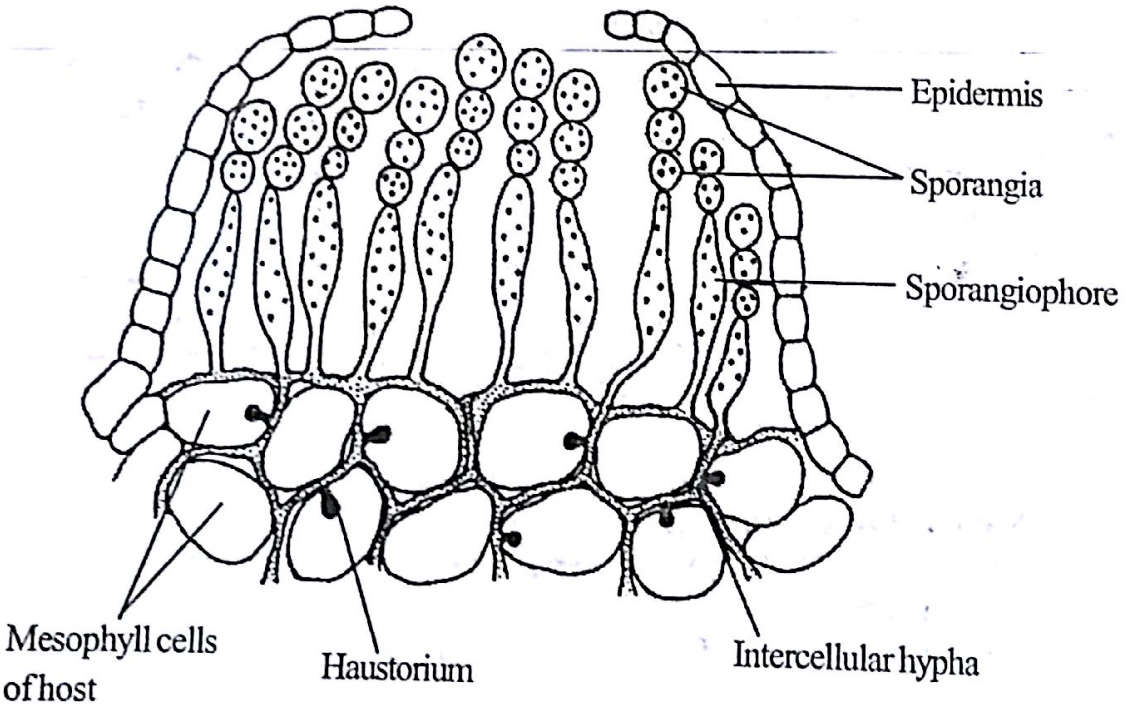

Fig.25.4: Albugo- A peripheral part of host leaf showing sporangial sorus

The sporangia are otherwise called ***conidia***.

They are produced in ***chains*** at the tips of the hyphae just ***below the epidermis***.

The part of the mycelium growing in the intercellular space, branches repeatedly and forms a compact mass of hyphae.

The tips of the hyphae become ***club - shaped*** with thick wall. They are called ***sporangiophores***.

They are upright and parallel to one another. Because of compact growth, they form a ***palisade - like layer*** below the epidermis.

Each sporangiophore develops a deep constriction near the tip, resulting in the formation of a ***sporangium*** at its tip.

The sporangium is ***hyaline*** and ***spherical*** in shape.

It is ***multinucleate*** and ***smooth.*** It may range from ***14*** to ***20m*** in diameter.

Immediately after the formation of the first sporangium, another sporangium is formed below the first sporangium.

Thus a chain of many sporangia is formed at the tip of each sporangiophore.

The adjacent sporangia are joined together by a mucilaginous pad called ***gelatinous disc*** or ***intercalary disc*** or ***disjunctor cell.*** This is formed by the ***gelatinisation*** of the outer sporangial wall.

The sporangia are ***basipetalous*** i.e. oldest sporangium at the tip and the youngest one at the base.

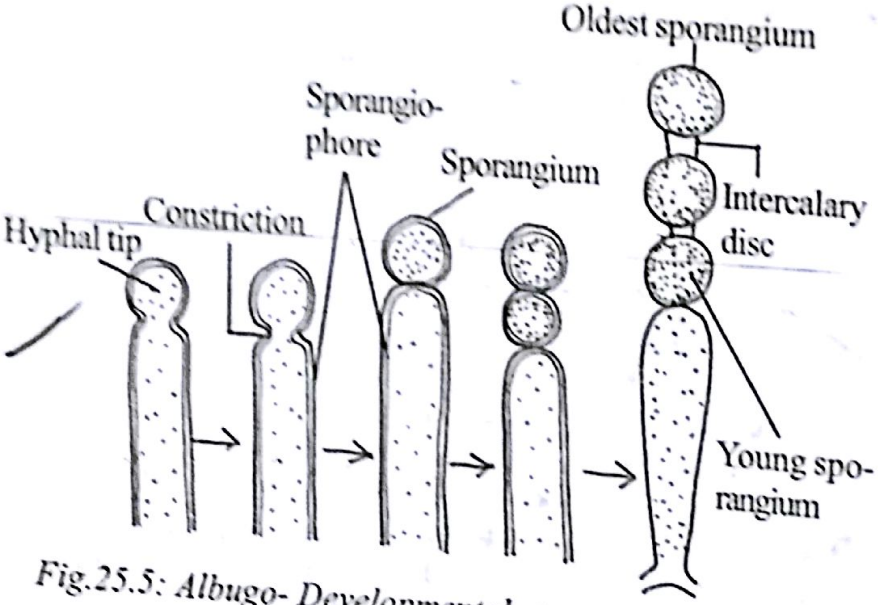

Fig.25.5: Albugo- Developmental stages of sporangium.

The continuous formation of sporangia excerts some pressure on the host epidermis. It gets lifted and then ruptured.

The white mass of ***sporangia*** is exposed out in patches. This is the characteristic feature of ***white rust*** disease.

The gelatinous intercalary disc dries up and gets disintegrated. The sporangia are released free and disseminated by ***wind.***

On reaching the surface of a suitable host, the sporangium germinates.

Thus 100 or more zoospores are produced inside the oospore.

The oospore (zoosporangium)comes out by the rupture or decay of host tissue. The oospore wall splits to release the zoospores.

When the zoospores come in contact with a seedling they loose flagella. A cyst wall develops. It remains dormant inside the cyst for some time. Then the spore germinates a tube called ***germ tube***. The germ tube penetrates the host plant and forms a mycelium therein.

Conclusion

In *Albugo,* vegetative plant body is a ***haploid mycelium*** (N).

It reproduces new haploid mycelia by means of ***sporangia*** **(N).** The sexual reproduction is ***oogamous.***

The male and female sex cells are ***haploid***.

The male and female nuclei fuse together and form a ***diploid zygote*** (2N).

The zygote undergoes ***meiosis*** to form ***haploid zoospores(N)***.

The zoospores germinate and give rise to ***new haploid mycelia***.

Thus there is a distinct ***haploid phase*** and ***diploid phase*** in the life cycle. This type of life cycle is known as ***alternation of generations***.

Control of *Albugo*

1.***Crop rotation*** with resistant crop varieties in order to avoid the survival of *Albugo* in the form of spores.

2.Cruciferous crops should be cleaned up.

3.Infected crop residues should be ***burned out.***

4.***Spraying fungicides*** such as 0.8% ***Bordeaux*** mixture over the crops is recommended.

5.Soil application of ***sulphur dust*** mixed with ***sawdust*** is used to destroy the zoospores of *Albugo.*

Life Cycle of *Albugo*

Albugo is an ***obligate parasitic fungus***.

It is included in the family ***Albuginaceae*** of the class ***Oomycetes.***

It causes ***white rust*** disease in many species of ***cruciferous plants***.

So it is popularly called ***white rust fungus*** .

There are about 25 species of *Albugo.*

The vegetative body of *Albugo* is a ***mycelium***. It is ***haploid (N).***

It ramifies in the intercellular spaces between the cells of the host.

The mycelium consists of many branched, septate, coenocytic ***hyphae.***

The hyphal cells are ***multinucleate.***

The hypha produces small knob-like structures called ***haustoria.***

The haustoria penetrate the host cells and absorb nutrients. The nutrition is ***heterotrophic***.

Reproduction

Albugo reproduces ***asexually*** as well as ***sexually***.

Asexual Reproduction

The asexual reproduction takes place by means of ***sporangia***.

They are borne on ***sporangiophores*** just below the epidermis of the host leaf.

Some parts of the mycelium growing in the intercellular spaces, branch repeatedly and form a ***compact mass*** of hyphae. This mass occurs below the epidermis. The tips of this hyphae become ***club - shaped*** with thick wall. They are called ***sporangiophores***.

They are arranged vertically in the form of a palisade layer.

Each sporangiophore develops a deep constriction near the tip, resulting in the formation of a sporangium at its tip.

The sporangium is ***hyaline, spherical, multinucleate*** and ***smooth - walled***. They are 14 - 20 m in diameter.

The second sporangium is produced below the first sporangium.

In this way a ***chain of sporangia*** is produced.

The sporangia are ***basipetalous***, i.e. oldest sporangium at the tip and youngest one at the base.

A mucilaginous ***intercalary*** disc is seen between the sporangia.

The continuous formation of sporangia excerts some pressure on the host epidermis.

So, it is lifted and ruptured.

A white mass of sporangia is exposed out in patches. This is the characteristic feature of ***white rust*** disease.

At maturity the intercalary disc dries up and gets disintegrated.

The sporangia are released free and disseminated by ***wind***.

Moisture and ***low temperature*** are found to be suitable for the ***germination*** of sporangia.

On reaching a suitable host, the sporangium swells and its content divides into 6 - 8 pieces.

Each piece has a single nucleus. It develops a ***cell wall*** and two ***flagella*** to become a ***zoospore***. It is uninucleate.

Thus 6 - 8 zoospores are produced in a sporangium.

When the sporangial wall ***ruptures***, the zoospores are released free .

The zoospores undergo some free movements and then come to rest on the leaf surface.

It produces a ***germ tube*** which enters the host through the ***stomata***. It later grows into a ***mycelium***.

Sexual Reproduction

The sexual reproduction is ***oogamous type***.

The male and female sex organs are called ***antheridia*** and ***oogonia*** respectively.

Albugo is ***homothallic***, i.e., antheridia and oogonia are borne on the same mycelium.

The formation of sex organs in the host petiole or stem leads to ***hypertrophy***, i.e., local swelling.

Oogonium

The oogonium is a ***globular multinucleate*** structure.

It is produced at the tip of short ***female hypha***.

It contains ***dense cytoplasm*** and plenty of ***reserve foods***.

It has many small ***vacuoles***.

The nuclei increase in number by ***mitotic*** division.

All nuclei, except one, move to the periphery (periplasm).

The central portion with the one nucleus becomes granular ***ooplasm***.

The ooplasm develops a ***plasma membrane*** around it and forms an ***oosphere***.

The oogonium is ***multinucleate*** and it contains ***dense cytoplasm*** and plenty of ***reserve foods***. It has many small ***vacuoles.***

As the oogonium matures, the nuclei undergo ***mitotic*** division.

The protoplasm differentiates into central ***ooplasm*** and outer ***periplasm***.

The ooplasm is dense and nucleated.

The ***periplasm*** on the other hand is clear and vacuolated.

After sometimes, the nuclei migrate from the ooplasm to periplasm and are distributed at the periphery of the oogonium.

In the meantime, only one nucleus remains in the centre of the ooplasm. The ooplasm develops a ***plasma membrane*** around and forms an ***oosphere***. The oosphere functions as the ***egg.***

At or just before fertilization, all peripheral nuclei start to disintegrate.Eg. *Albugo candidus.*

In some species, the oogonium has more than one egg nucleus. Eg. *Albugo platensis, Albugo bliti,* etc.

Antheridium

Antheridium is the ***male sex organ.***

It is an elongated ***club-shaped*** structure produced at the tip of ***male hypha.***

It is found close to the oogonium.

It is cut off from the male hypha by a ***septum***.

It is ***multinucleate.***

Although it has about 12 nuclei, only one is functional and acts as the ***male nucleus.***

Fertilization

The antheridium bends and comes in contact with the ***oogonium.***

At the site of contact, the oogonium produces a small protuberance called ***receptive spot*** or ***receptive papilla.***

The wall of the oogonium and antheridium becomes thin at this site.

A slender tubular outgrowth arises from the antheridium, pierces the receptive papilla and grows into the oogonium. It is called ***fertilization tube.***

A dense cytoplasmic granule develops in the centre of the ooplasm. It is called ***coenocentrum***. The female nucleus is found attached with it.

The fertilization tube grows until its tip reaches the ooplasm.

When it reaches the coenocentrum, the tip of the fertilization tube ruptures and releases the male nucleus into the ooplasm.

The male and female nuclei fuse together and form a ***diploid nucleus.***

After fertilization,the fertilization tube disintegrates and the coenocentrum disappears. The fertilized egg is called ***zygote.***

Oospore

2N After fertilization the zygote secretes a thick wall around it and becomes an ***oospore.***

The oospore has a ***diploid nucleus*** *(2N).*

Germination of Oospore

The oospores are set free after the decay of the host tissues.

The diploid nucleus undergoes ***meiosis*** and then three ***mitotic*** divisions. As a result, 32 ***haploid nuclei*** are formed. The oospore then takes rest for some time.

Later, the oospore absorbs moisture and swells up. Its nucleus divides repeatedly so as to form 100 or more nuclei. Each of the nuclei gets a piece of cytoplasm to become a ***biflagellate zoospore.***

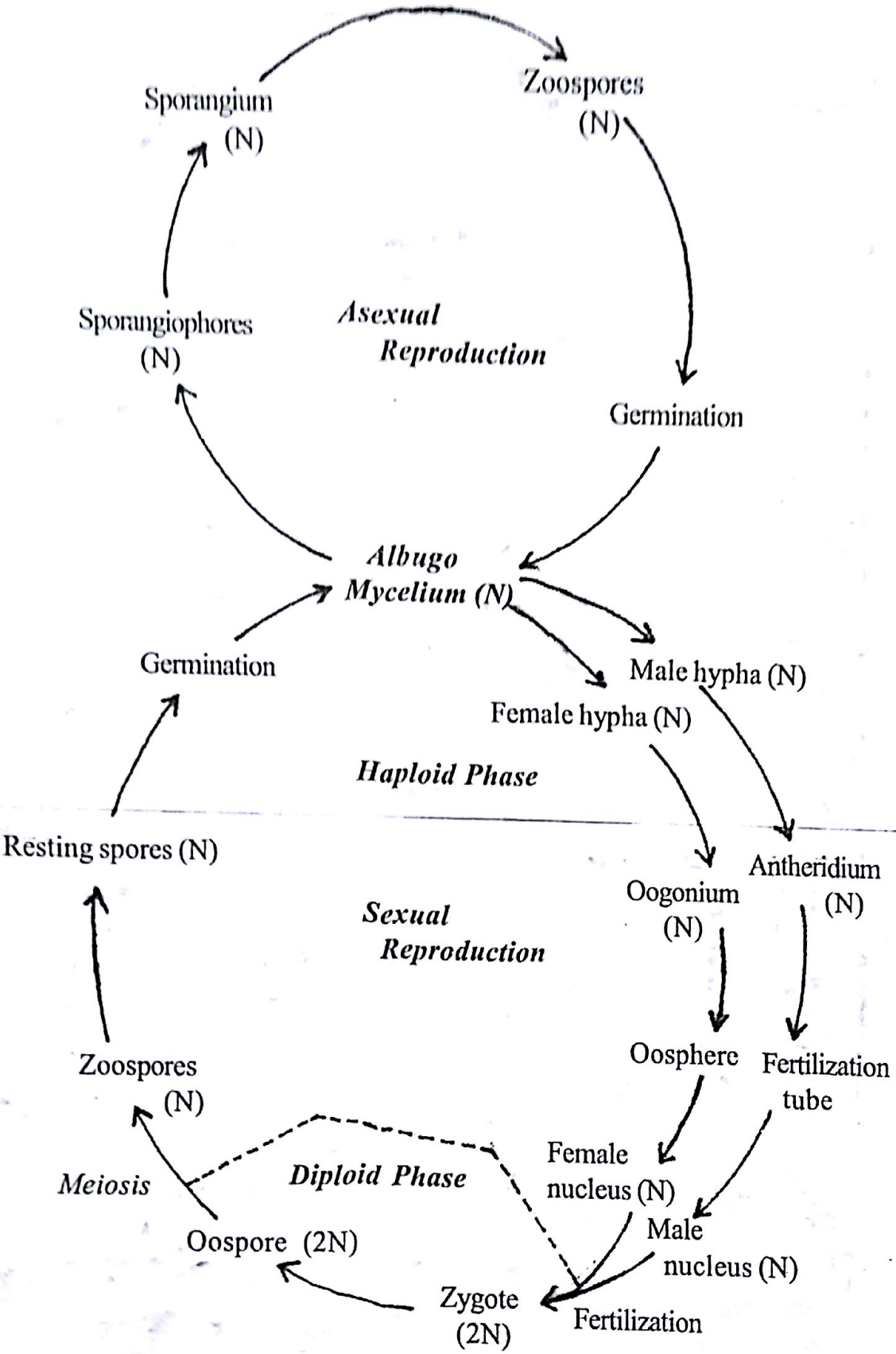

Fig.25.8: Graphic life cycle of Albugo.

• The sporangiophore develops a series of ***sporangia*** at its tip.

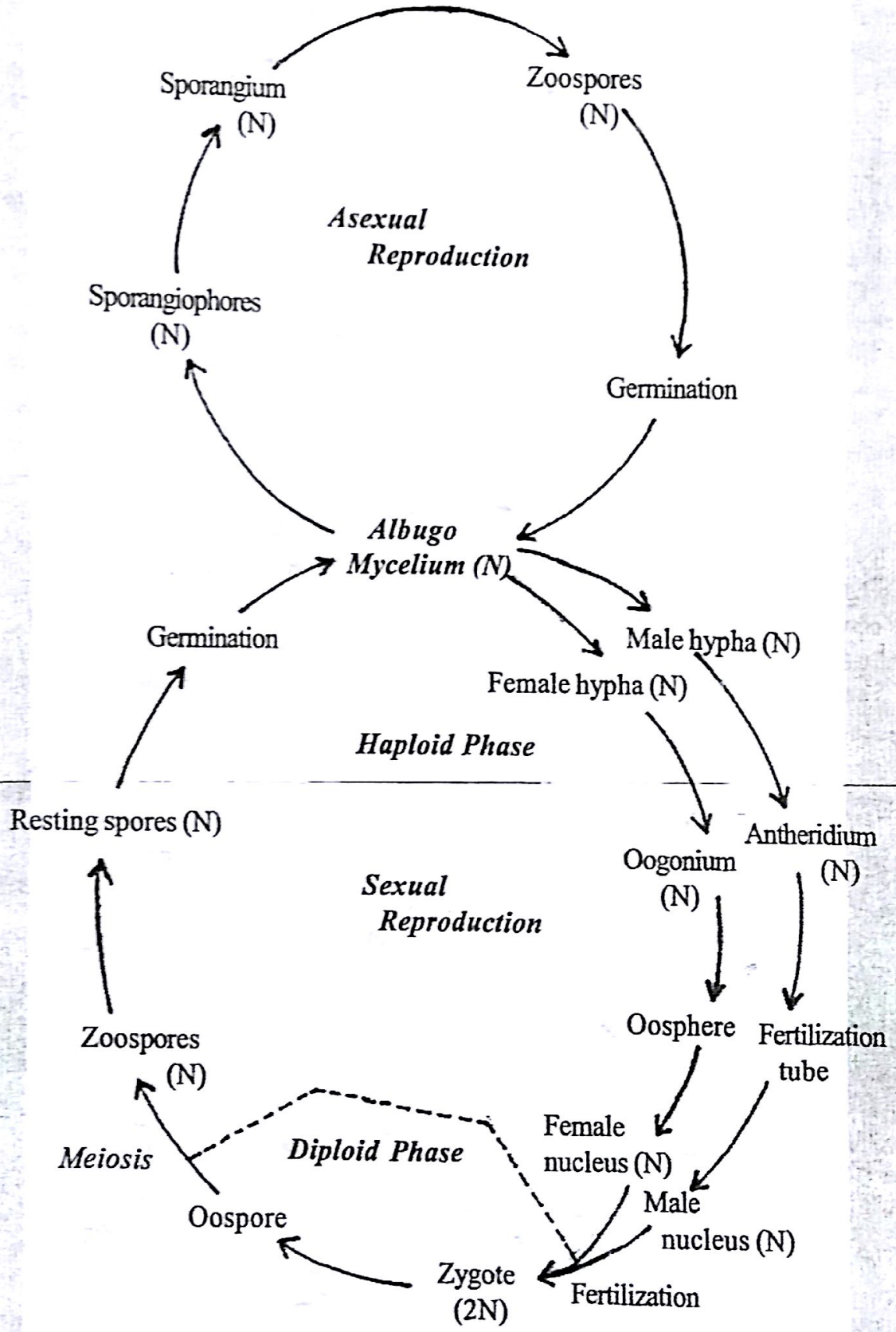

Fig.25.10: Graphic life cycle of Albugo.

- The sporangium is ***hyaline*** and ***spherical*** in shape.
- It is ***multinucleate*** and ***smooth***.
- The sporangia are joined together by a ***mucilaginous*** pad called ***gelatinous disc*** or ***intercalary disc***.
- The sporangia are arranged in ***basipetalous manner***.
- Each sporangium develops 6 to 8 uninucleate ***zoospores***.
- The continuous formation of sporangia, ruptures the host epidermis and the white mass of sporangia is exposed.
- The sporangia are released free and disseminated by ***wind***.
- On reaching the suitable host, the sporangial wall ruptures and releases the ***zoospores***.
- The zoospores swim in water and lose their flagella.
- The zoospore produces a ***germ tube*** and penetrates the leaf.
- It grows into a new ***mycelium***.
- Sexual reproduction is ***oogamous type***.
- *Albugo* is ***homothallic***.
- The male sex organs are called ***antheridia*** and they are borne on the ***male hypha***.
- The female sex organs are called ***oogonia*** and they are borne on the ***female hypha***.
- The oogonium is ***multinucleate***.
- Only one nucleus becomes functional and it remains in the centre of the ***ooplasm***. All the other nuclei disintegrate.
- Antheridium of *Albugo* is ***multinucleate***.
- It has 12 nuclei, only one is functional and acts as the ***male nucleus***.
- The antheridium comes in contact with the oogonium.
- At the point of contact the oogonium produces a small protuberance called ***receptive papilla***.
- The antheridium produces a ***fertilization tube*** that pierces the receptive papilla and grows into the oogonium.
- The tip of the fertilization tube ruptures and releases the male nucleus into the ***ooplasm***.
- The male and female nuclei fuse together and form a diploid ***nucleus***.
- The fertilized egg is called ***zygote***.
- The zygote secretes a thick wall around it and becomes an ***oospore***.
- The oospore has a diploid nucleus.
- The diploid nucleus undergoes ***meiosis*** and ***mitosis*** to form, 32 haploid ***zoospores***.
- The zoospores are released by the rupture of oospore.
- The zoospores germinate into ***mycelium***.
- In the life cycle, haploid vegetative thallus alternates with the diploid oospore. So there is ***alternation*** of ***generations***.

Antheridium

The antheridium is a *club - shaped* structure with many nuclei.
It is produced at the tip of *male hypha* near the female hypha.
Although it has about 12 nuclei, only one acts as the *male nucleus*.

Fertilization

The antheridium comes in contact with the oogonium. At the point of contact, a small receptive papilla develops on that oogonium.

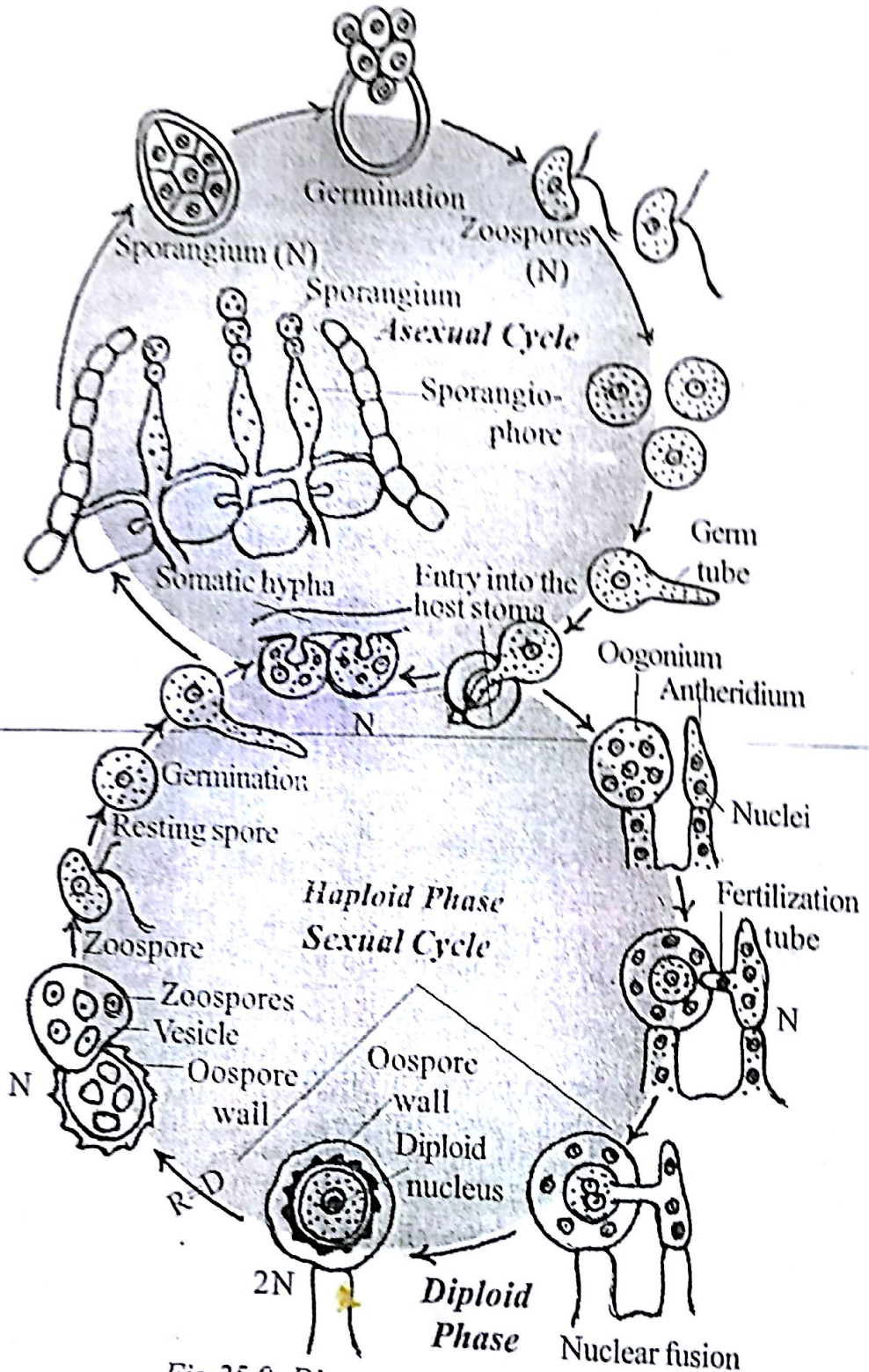

Fig.25.9: Diagrammatic life cycle of Albugo.

The wall becomes very thin.

A slender tubular outgrowth arises from the antheridium and pierces the ***receptive papilla***.

It grows until it reaches the granule ***coenocentrum*** in the oosphere. This tube is called ***fertilization tube***.

The fertilization tube ruptures and releases the male nucleus into the ooplasm.

The male and female nuclei fuse together to form a ***diploid nucleus*** (2N).

The fertilized egg is the ***zygote***. The zygote then secretes a thick wall around it to become an ***oospore***.

This is the ***diploid phase*** in the life cycle.

After having a period of rest, the diploid nucleus undergoes ***meiosis*** and then several ***mitotic*** divisions to form many nuclei.

It produces many uninucleate ***biflagellate zoospores***.

Now the oospores are released by the decay of host tissue.

When the oospore wall ruptures, the zoospores are released free in the soil.

They reach the seedlings and produce ***germ tubes***.

The germ tube enters the host and forms a ***mycelium***. It is ***haploid***.

Conclusion

Albugo is a ***haploid*** coenocytic ***mycelium(N)***. It reproduces asexually by ***sporangia*** (N).

By sexual fusion of antheridium with oogonium a diploid oospore is formed. This is the ***diploid phase*** (2N).

The diploid nucleus undergoes ***meiosis*** and forms ***haploid meiozoospores***.

Each haploid meiozoospore gives rise to a new haploid mycelium.

Thus the ***haploid phase*** alternates with the ***diploid phase*** in a regular manner. This type of life cycle is called ***alternation of generations***.

Highlights

Life Cycle of Albugo

- *Albugo* is a ***fungus***, included in the class ***Oomycetes***.
- It is popularly called ***white rust fungus*** because it causes ***white rust disease*** on land plants.
- All species of *Albugo* are ***parasitic***.
- The vegetative body of *Albugo* is ***haploid (N)***.
- The plant body is a ***mycelium***.
- The mycelium consists of many ***branched, septate, coenocytic hypha***.
- The hyphal cells are ***multinucleate***.
- The hypha produces knob-like ***haustorium***.
- The haustorium penetrates the host cell and ***absorbs food*** materials.
- Nutrition is ***heterotrophic***.
- *Albugo* reproduces ***asexually*** and ***sexually***.
- The asexual reproduction takes place by ***sporangia***.
- The hypha produces vertical branches called ***sporangiophores***.
- They are ***club-shaped***.